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TITLE: SOVIET WATER POLICY MANAGEMENT:
Origins and Implications of the
Current Crisis

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NOTE

This report is the second of three related papers dealing with Soviet environmental problems, mainly in the field of water resources. The papers are:

1. "Policies to Control Water Pollution, 1917-72: Agenda Setting in the USSR," Ronald D. Oechsler.

2. This report.

3. "Water Policy Mismanagement in the Southern USSR: The Ecologic and Economic Impact," Michael A. Rozengurt.

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EXECUTIVE SUMMARY

This report discusses the failure of Soviet water management policy and practices over the past three decades that has led to an unprecedented crisis in agriculture, salinization of arable land, near destruction of fisheries and other natural resources, and, most importantly, the lack of drinkable water for millions of Soviet citizens.

Water has played a particularly critical role in the economic development of the USSR. Not only have water and hydropower been considered crucial elements for large-scale industrial growth of the country, but water has also been considered the key to success in land reclamation, an important feature of Soviet agricultural development. However, huge investments in irrigation programs have failed to provide adequate food for the population of the USSR. On the contrary, excessive use of irrigation throughout the years of Soviet rule has resulted in massive soil salinization and irretrievable loss to agriculture of 3 to 5 million hectares of arable land, with another 9 million hectares in semi-arid zones of the USSR requiring highly expensive reclamation work. The most fertile croplands in the Dnieper, Don and Volga River valleys have been flooded by hydropower storage or have become exhausted due to lack of crop rotation. In the USSR as a whole, annual losses to erosion cost 8% to 10% of total agricultural production. For example, in the Central Russian Plains 10 to 15 cm of topsoil have disappeared over the last 30 to 40 years. Rain and melting snow annually carry off 80 to 120 million tonnes of topsoil. In general, over 25% of Western Soviet farmland has suffered from

salinization and erosion to the point of significant geomorphologic reconstruction of the land.

Agricultural, industrial and municipal water pollution of the middle and lower parts of rivers in Moldavia, Ukraine, the southern RSFSR, and Soviet Central Asia has reached extreme levels. In 1986, toxic industrial effluents amounting to 15 km^3, and another 6.5 km^3 of raw sewage, were let into European Soviet streams. This is a severe blow to the river environment as only 1 km^3 of raw sewage contaminates 60 km^3 of clean water. Therefore, almost all the Soviet usable water supplies are affected. Many rivers, their tributaries, and local streams have become ditches carrying multi-colored sewage and industrial wastes; others have dried up or become saline.

At the same time, healthy and highly productive riverine and estuarine habitats of south-flowing rivers have been destroyed by a series of dams that have interfered with the reproduction and survival of many commercially valuable anadromous and semi-anadromous fish. Large irretrievable losses of the water supply and abnormal redistribution of seasonal runoff patterns have contributed to the drastic decline of commercial fisheries in the southern seas of the USSR and their estuarine systems.

The Aral Sea (Soviet Central Asia) is the most vivid example of single-minded mismanagement of water and living resources that has led to complete destruction of the river-delta-sea ecosystem and surrounding arable land. In addition, many hundreds of kilometers of unique sand bars and beaches of the Black, Azov and

Caspian Seas have been lost through pollution of coastal waters by municipal outfalls and returning agricultural discharges. Excessive excavation and construction errors have also led to a many-fold decrease of sediment load from their rivers as a result of excessive river impoundment.

Ecological concerns were exacerbated by the 1986 nuclear accident at Chernobyl, located on the Pripiat tributary of the Dnieper River, as well as by recent reassessments of earlier less damaging accidents, including the 1957 explosion at a radioactive waste dumping site near Cheliabinsk in the Ural Mountains river watersheds. The safety of all nuclear power plants in the vicinity of populated river basins or adjacent coastal sea zones has become questionable.

Fortunately, Soviet authorities have at long last begun to appreciate the gravity of the country's ecological problems, including those related to water. Awakened by the increasingly obvious signs of environmental degradation and its subtle but insidious and eventually massive cumulative impact on the health of the population, the Soviet government spent over 60 billion dollars from 1975 to 1986, double the expenditure for the preceding ten years, on environmental preservation and restoration in European USSR and Western Siberia.

However, as detailed in this report, the past failures of Soviet water policy management have left the country with profound difficulties, the long-term consequences of which will have major impacts. The implementation of new principles of balanced

development of natural resources will require the retraining, re-employment and replacement of large groups, the introduction of new information technologies, the assimilation of Western experience and technology in economic and environmental management, decentralization of control, and the introduction of a new system of economic incentives, such as pricing, for the preservation of natural resources. Success is uncertain and the outcome remains to be seen.

I. INTRODUCTION

The USSR, which occupies one-sixth of the world's land mass and stretches over several climatic zones, is one of the few countries in the world where the massive use and reshaping of natural resources can engender noticeable modifications in the global environment as well as the ecological and economic well-being of the country itself. This complex interaction of man and the environment, fraught with the risk of unintended consequences, is the subject of this report.

The field of modern ecology, to which Soviet researchers have made valuable contributions, demonstrates that various processes occurring in the atmosphere, hydrosphere and biosphere are intimately linked. These three dynamic envelopes of the Earth compose a single multicomponent system. Attempts to interfere with this system, to isolate a natural resource and regulate it by technical means regardless of its natural limitations, will invariably cause disruption in all links of natural cycles of the environment. A combined economic-ecological system operates as a self-sustaining mechanism in which an initial disturbance is amplified as it passes through the system until, during some later cycle, either the economic or environmental component collapses should that disturbance repeatedly occur.

In the USSR, at each stage of its economic development, this problem has been compounded by a political machine driven by the

far-fetched dogmas of "scientific communism," one of which is a belief in the inexhaustibility of natural resources. This postulate stands in direct conflict with the worldwide understanding of the urgent necessity to maintain balanced ecological, social, and economic development recognizing definite limitations on the renewability of resources, notably the fresh water supply.

In a relatively short period of time, the Soviet Union developed into the second largest industrial state in the world, but at the cost of the unrestrained, wholesale destruction of natural wealth (Komarov, 1980; Gustafson, 1981; Pryde, 1972, 1983; Minkin, 1986; Lushin, 1988 Kotliakov, 1988, Shcherban, 1987, Novy Mir, 1987; Algul'n, 1988). General deterioration of the environment and systematic pollution have plagued the Soviet Union at every turn of its economic development. These catastrophes have resulted from miscalculations on the part of Soviet leaders, compounded by the unavoidable consequences of technological progress.

Water has played a particularly critical role in the economic development of the USSR. Not only have water and hydropower been considered crucial elements for large-scale industrial growth of the country, but water has also been considered the key to success in land reclamation, an important feature of Soviet agricultural development. However, huge investments in irrigation programs have failed to provide adequate food for the population of the USSR (Medvedev, 1987; Fedorov, 1987). On the contrary, excessive use of irrigation throughout the years of Soviet rule has resulted

in massive soil salinization and irretrievable loss to agriculture of 3 to 5 million hectares of arable land, with another 9 million hectares in semi-arid zones of the USSR requiring highly expensive reclamation work (Kharchenko, 1975; Kovda, 1984). The most fertile croplands in the Dnieper, Don and Volga River valleys have been flooded by hydropower storage or have become exhausted due to lack of crop rotation (Kovda, 1981; Velichko, 1984; Yanshin et al, 1984). In the USSR, annual losses to erosion cost 8% to 10% of total agricultural production. For example, in the Central Russian Plains 10 to 15 cm of topsoil have disappeared over the last 30 to 40 years. Rain and melting snow annually carry off 80 to 120 million tonnes of topsoil (Oldak, 1987). In general, over 25% of Western Soviet farmland has suffered from salinization and erosion to the point of significant geomorphologic reconstruction of the land (Dukhovny, 1984; Kolpakov and Sukharev, 1988).

Agricultural, industrial and municipal water pollution of the middle and lower parts of rivers in Moldavia, Ukraine, the southern RSFSR, and Soviet Central Asia has reached appalling levels (Soviet Digest, 1987, 1988; Tolmazin, 1985; Lemeshev, 1988; Micklin, 1988). In 1986, toxic industrial effluents amounting to 15 km^3 and another 6.5 km^3 of raw sewage were let into European Soviet streams. This was a severe blow to the river environment as only 1 km^3 of raw sewage contaminates 60 km^3 of clean water. Therefore almost all the Soviet usable water supplies are affected (Lemeshev, 1988). Many rivers, their tributaries, and local streams have become ditches carrying multi-colored sewage and

industrial wastes; others have dried up or become saline (Goldman, 1972; Gusev, 1975; Komarov, 1980; Vendrov, 1979; Pryde, 1983; Zalygin, 1987; Sokolov, 1987).

At the same time, healthy and highly productive riverine and estuarine habitats of south-flowing rivers have been destroyed by a series of dams that have interfered with the reproduction and survival of many commercially valuable anadromous and semi-anadromous fish (Berdychevsky, 1975; Bronfman, 1985; Volovic, 1986; Rozengurt and Hedgpeth, 1989). Large irretrievable losses of the water supply (Table 1)* and abnormal redistribution of seasonal runoff patterns have contributed to the drastic decline of commercial fisheries in the southern seas of the USSR and their estuarine systems (Rozengurt, 1969, 1974, 1983, 1987, 1989; Bronfman, 1977; Bronfman and Khlebnikov, 1985; Tolmazin, 1985).

The Aral Sea (Soviet Central Asia) is the most vivid example of single-minded mismanagement of water and living resources that has led to complete destruction of the river-delta-sea ecosystem and surrounding arable land (Baidin, 1980; Ogonek, 1988; Micklin, 1988). In addition, many hundreds of kilometers of unique sand bars and beaches of the Black, Azov and Caspian Seas have been lost through pollution of coastal waters by municipal outfalls and returning agricultural discharges. Excessive excavation and construction errors also have led to a many-fold decrease of sediment load from their rivers as a result of excessive river impoundment.

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*All Tables and Figures are grouped together on pages 44 ff.

Ecological concerns were exacerbated by the alarming 1986 nuclear accident at Chernobyl, located on the Pripiat tributary of the Dnieper River, as well as by recent reassessments of earlier less damaging accidents, including the 1957 explosion at a radioactive waste dumping site near Cheliabinsk in the Ural Mountains river watersheds (Medvedev, 1979). The safety of all nuclear power plants in the vicinity of populated river basins or adjacent coastal sea zones has become questionable (Aleksakhin, 1982).

Fortunately, Soviet authorities have at long last begun to appreciate the gravity of the country's ecological problems, including those related to water. Awakened by the increasingly obvious signs of environmental degradation and its subtle but insidious and eventually massive cumulative impact on the health of the population, the Soviet government spent over 60 billion dollars from 1975 to 1986, double the expenditure for the preceding ten years, on environmental preservation and restoration in European USSR and Western Siberia (Lemeshev, 1988). In other words, direct and indirect expenditures attributed to preservation and partial restoration of the environment reached 1.4% to 2.0% of the Soviet Gross National Product for the period 1975-1987.

However, as we shall detail in this report, the past failures of Soviet water policy management have left the country with profound difficulties, the long-term consequences of which will have major impacts not only on the USSR but on the United States and other countries as well.

II. SOVIET ENVIRONMENTAL POLICY

After the First World War and October Revolution had run their courses, the economy of the Soviet nation was in a state of upheaval. Soviet leaders declared that Soviet-type socialist systems were the inevitable and scientifically predictable outcome of a world-wide socio-economic revolution as described by Karl Marx. To prove this to the outside world, however, economic success had to be gained, at any price, and little thought was given to the rational use of natural resources. "Obuzdat' stikhiiu!" ("harness the elements!") was the operative slogan as Soviet leaders embarked on a course of economic development based in part on the unlimited exploitation of natural resources.

The implementation of large-scale integrated water development programs was of particular importance. It was hoped that the effective manipulation of water projects would solve a number of the country's political, economic and long-term strategic problems, specifically by boosting food and energy supplies. Belief in the inexhaustibility of the river water supply held an extraordinary fascination for Soviet officials, and for many years it remained an undisputed dogma.

By the 1950s this attitude was well-entrenched in Soviet water management policy. Water development projects during this time, and onward up to the present, underscored the fact that proponents of unlimited development of hydroelectric power plants and irrigation systems were too inexperienced to deal with the massive changes effected by ill-planned construction.

As we shall see, the development and implementation of water programs have been hindered both by the doctrines of "scientific communism" and by a political system blind to the course of nature. In the rush to fulfill party directives, adequate risk assessment analyses were not made and the foundation for environmental decay was laid.

The Environmental Doctrines

In the 1920s and 1930s, the voluntaristic ways and means of economic development based on the theoretical works of Karl Marx and Friedrich Engels were adopted without reservation by Lenin and his successors. The Communist Party announced that the "reordering" of natural realms would demonstrate the might of the first socialist nation to confront the forces of "wild nature"--forces that had to be mastered to achieve a glorious, socialist "bright future". The resulting theories were refined in later years to meet new conditions and termed the "laws of scientific communism" (Stalin, 1951; Bezanson, 1984). Stalin's ideologists believed that this theory provided guidance for all practical economic actions, including those related to the environment. However, in the case of environmental management, the application of the "laws of scientific communism" was complicated by the necessity to account for the laws of nature and to have them adjusted to the radical requirements of the communist state--regardless of natural limitations of living and non-living resources in the surrounding environment. To achieve their goals,

Soviet ideologists circumvented nature-related "snags" by formulating three major "enviro-ideological doctrines" or concepts. These three concepts, which provided a theoretical basis for the assimilation of nature's laws into the production systems of administrative dictates, were the following:

- o natural resources are inexhaustible
- o the leading sector of a state economy exercises all rights to resource development and use
- o multipurpose use of resources must not be restricted by losses sustained by the surrounding environment if resources development is justified by strategic or state political goals

The first doctrine was applied to the freshwater supply from rivers to justify the unlimited use of runoffs in the development of strategically important networks of navigable canals and power plants in the European part of the USSR (Figure 1).

The concept of the inexhaustibility of water resources ignored, among other things, the fact that in industrialized societies, freshwater swiftly moves from the category of an environmental component to that of a complex raw material or mineral. In other words, water needed for human and technological consumption can be used only after undergoing special purification processes similar to those for other raw materials, such as ore, coal, and oil. In this context, freshwater resources require expenditures of energy and labor for their restoration and production (Khachaturov, 1982; Oldak, 1983, 1987). For example,

in order to conserve 1 km^3 of freshwater leaking from unlined canals in Central Asia, the federal and local governments must spend about $2 to $3 billion dollars, and an additional $5 to $7 billion is required to restore one million hectares of formerly irrigated land (All-Union Institute GIPROVODKHOZ, 1987; Novy Mir, 1987; Milanova and Rybshikov, 1986).

The second doctrine (enviro-ideological) assumed that any given renewable resource could be used for many purposes and at the same time be protected from degradation if a designated "leading sector" of the economy would be solely responsible for the management and control of resources development among other users. However, as practice has shown, stewardship over freshwater resources has been determined more by political campaigns or strategic goals than by local needs (Vendrov, 1970).

In the late 1940s and 1950s, water development was pursued in two major directions: (1) construction of unified energy and shipping channel systems, and (2) the maximum seasonal water accumulation behind a series of dams built on major rivers in the European part of the USSR (Vendrov, 1970). Note that energy output from these facilities was planned primarily for use by military-industrial complexes located in the regions of Leningrad, Moscow, Kiev, Dnepropetrovsk, Nikolaev, Taganrog, Rostov-on-Don, Kuibyshev, Stalingrad, Baku and Krasnoiarsk. At the same time thousands of villages and small towns were deprived of electricity and were forced to provide their own energy supply by using inadequate diesel-generator facilities. Construction of

hydropower plants (such as the Volkhovskii and Dnieproges power plants) gradually became a leading sector of the Soviet economy. Consequently, river impoundment became a principal instrument of this policy (Vasilev and Khrisanov, 1984).

The third doctrine. By the end of the 1950s, the first stage of multi-purpose water-use projects (combining power plants, shipping, flood control, industrial and municipal water supply) was upgraded to the rank of **kompleksnoe ispol'zovanie** (L'vovich, 1974; Zuzik, 1973; Fedorov, 1977), that is, all ways and means of resources utilization, or comprehensive use. This approach expanded the exploitation of natural resources that included, but was not limited to, irrigation networks in the semi-arid and arid regions of the southern USSR by means of inter- or intra-basin water transfer facilities (Table 2).

Economic Development, Politics, and the Environment

At the end of Stalin's rule and during the Khrushchev and Brezhnev periods all large-scale development projects were run as "campaigns" under ideological cover and immediately acquired the status of velikaia stroika kommunizma (great construction of communism), or udarnaia stroika kommunizma (urgent construction of communism). Such a strategy gave the central government unlimited flexibility in decision-making in terms of human, financial and industrial resource allocation--regardless of regional needs and variations. In other words, the slogan "udarnaia stroika kommunizma" become the basis for justifying the

political and strategic necessity of large-scale resource development projects in order to expedite the implementation of Party directives that were aimed at matching the economic strength of the USA and other western countries.

Despite some distinct achievements, this political campaign, which in reality was one of economic "all-purpose" development, drained resources and manpower from established users and local industries, wreaked havoc on the economies of the Republics, and inflicted substantial losses to the environment (XIX Communist Party Conference).

This highly politicized approach often superseded any Soviet environmental legislation, rendering it powerless to enforce measures that could have mitigated environmental damage. This occurred despite the fact that Soviet water legislation lists the improper management of water resources as a punishable action. Punishable violations include the lack of control and negligence in the operation of hydrotechnical facilities, pollution above permissible norms, mismanagement of irrigation networks, and contamination of inland and coastal waters (Kolbasov and Krasnov, 1985; Sakhaev and Scherbitsky, 1986).

In practice, environmental laws were applicable primarily to local, small-scale, readily observable violations. At the same time, the disruption of large-scale natural cycles caused by Federal and Republic projects was claimed to be an inevitable price of the modernization of agriculture and industries in order to attain a stable harvest and an opportunity to produce, if not

exceed, the food output of the developed countries. Furthermore, it was considered that the success or failure of this policy would have a strong ideological impact on the vitality of communist doctrines in eastern and developing countries.

Besides the "campaign" approach to development, there were other forces that were responsible, in part, for the progressive degradation of the environment. Part of the problem stemmed from the lack of professional education among political and managerial bosses of the 1940s, 1950s, and 1960s. Some 75% to 80% of the top Provincial and Republic secretaries and members of the Central Committee did not have an appropriate higher education. Their choices of scientific consultants were often inadequate, and those selected often suffered the ambiguity of an inadequate understanding of ecology and unshakable dedication to political goals. These "specialists" in their institutional surroundings manipulated economics and environmental sciences over three decades and were the predominant contributors to the steady destruction of many natural systems and, consequently, the welfare of the country. All too often environmental "specialists" formulated scientific goals to match their political patron's desired results.

It is no secret that during Stalin's era thousands of environmental specialists of high integrity disappeared because they dared to raise their voices or warn against superficial recommendations and oversimplified statements on resource protection expressed by irresponsible scientific conformists.

Even as late as the 1970s the voices of non-conformists in the scientific community who foresaw impending environmental and economic disasters, such as the Danube-Sasyk canal, were ignored. Moreover, the numerous advanced environmental laws promulgated during the 1950s and 1960s were treated with such hypocrisy that anyone who dared to criticize the water establishment and its irresponsible actions during Khrushchev's and especially Brezhnev's era risked being labeled a trouble-maker and forced to resign his or her position, or was demoted. Those who wrote "desirable" environmental and economic assessments of proposed projects were promoted by their Party leaders.

The dominance of conspicuous political incompetence over the integrity of science softened somewhat during the first decade of Brezhnev's era. In the late 1960s the Academy of Sciences made public the results of its special committee which investigated the role of conformist ecologists' activities under T. D. Lysenko's leadership. The Committee noted a progressive retardation of the science of ecology and many other fields in the environmental sciences in the USSR (Proceedings Academy of Sciences, No. 11, 1965, Moscow), and the evaluation brought about the downfall of many responsible for wrongdoing. Since that time, many new faces in the political and scientific establishment have begun to promote the idea that "a professional corps is fundamental to assure our future." Though this pronouncement met with rather strong opposition among old Party stalwarts, its gradual implementation resulted in conspicuous changes in leadership in

many ministries and branches of the Academy of Sciences. Directors, principals and leading specialists could be appointed only if they had an education, professional training and experience commensurate to their assigned responsibilities. Nevertheless, the last ten-year period of political and economic stagnation gave rise to a neo-conformist style of environmental consultancy and remains entrenched in many institutions in Federal and Republic governments. These pseudo-specialists disregarded the universal laws of physics, hydraulics and hydrodynamics and provided "scientific" support for the "party line" in order to preserve their own careers and well-being. For example, the Moscow Institute of Water Problems, and the Hydroprozhekt of the Ministries of Water Industry of the USSR and Agriculture of UkrSSR and Soviet Central Asia, had consultants who were well paid and promoted despite the fact that they made inadequate environmental assessments and recommendations that complemented the ambitions of some powerful and unscrupulous members of the Politburo and others in the Party and government institutions. The obvious signs of cause/effect destruction of many formerly productive bodies of water and millions of hectares of arable lands lying between the Black and Aral seas were completely ignored. The political and pseudo-specialists' illiterate approach to environmental work is convincingly illustrated by the fact that some 2,600 villages and 165 towns have ended up at the bottom of man-made reservoirs since the advent of Soviet water resource development.

It is possible to assume that even under the current umbrella

of perestroika, obvious contradictions between the scientific integrity of a project and its practical results may continue to exist for a variety of reasons: (1) institutional deficiencies in the Soviet system, (2) the rivalry among various groups in the Central Committee and Politburo, for example, or between the "agricultural coalition" and the "energy lobby", (3) the hasty abandonment of economic methods and programs that do not immediately succeed in increasing industrial output, (4) the preference for quantitative growth over quality, and (5) the launching of a large number of capital projects with long-term expectations that inhibit modernization.

III. PROBLEMS AND STRATEGIES IN WATER RESOURCES MANAGEMENT

The incorporation of the "environmental doctrines" into Soviet economic planning has played a significant role in the modernization of the Soviet Union by creating a relatively stable water supply and reducing the amount of flood-induced damage in river valleys of European and Soviet Central Asia, and by increasing energy production and agriculture potential in the southern part of the USSR (Sokolov, 1985; L'vovich, 1984). Unfortunately, the unintended negative consequences have been vast and complex.

Irrigation

Approximately 65% of the agricultural areas of the USSR are situated in arid and semi-arid zones, including over 78% of hayland and 93% of pastures. The agricultural region with a $+5^{o}C$ average temperature encompasses 60% of arable land compared with only 10% in the USA. Annual precipitation of 700 mm or more falls on 1.1% of the arable land (vs. 60% in the USA); 400 mm is spread over 40% of arable land in the Soviet Union vs. 11% in the United States (Table 3, 3a; Khachaturov, 1985). In an effort to optimize the use of fertile lands located in semi-arid and arid zones, an irrigation program was created by executive order of the Central Committee of the CPSU in May 1966.

The Soviets believed that a large-scale irrigation network would be the only way to (1) mitigate the effects of frequent subnormal years of water supply on agricultural and other water users, (2) eliminate the dependence of the USSR on the international food market (Figure 2) and (3) honor obligations in supplying food to eastern and developing countries.

Since the 1960s between $5 billion and $7 billion per year have been allocated to bring about the accelerated construction of dams, an irrigation network in the south, the reclamation of wet and acidic land, and the intensive use of chemicals (although the use of chemicals has accelerated the depletion of freshwater sources despite the expenditure of almost $144 million on preservation projects).

Serious miscalculations were made in predicting the long-term

effects of supplying excessive amounts of water for irrigation. In the early 1970s authorities discovered that over 50% of diverted freshwater was irretrievably lost due to non-productive use in the out-of-date irrigation network. Water deficits became so pronounced, particularly in low-flow years (Table 4), that not all hydropower stations could produce enough electricity to meet designed capacity. The gigantic Kakhovskaia powerplant on the lower Dnieper River is a case in point. Such cases were especially evident in Central Asia and South Kazakhstan where they amount to between 45 km^3 and 49 km^3.

Agriculture annually consumes 180 km^3 to 190 km^3 of water out of the 300 km^3 to 350 km^3 used in the USSR as a whole, and approximately 78% of that is dedicated to recharging the irrigation network. However, only 40% of this latter volume reaches the plant. The other 60% is lost to seepage, evapo-transpiration and flushing salt from fields which have accumulated a staggering amount of it due to the excessive use of chemicals and water.

In the UzSSR, which has one of the largest irrigation networks in the world, only 8% of 183,000 km of channels are lined. In southern Kazakh SSR and Turkmen SSR, the lined canals amount to only 2% to 3% out of tens of thousands of kilometers of canals. As a consequence, over 40% of all water withdrawn into Soviet Central Asian irrigation and storage networks is lost to seepage (Oldak, 1987). The most extensive use of water occurs in Uzbekistan where 80% of total river runoff is used; Ukraine,

Moldavia, Kazakh SSR and Azerbaizhan use 50%, and in the Armenian and Turkmenian SSRs, the figure stands at 35%.

In addition, rapid growth in water consumption by industrial and municipal sectors has created man-induced contamination of watersheds. This problem was further compounded in the late 1960s when Soviet authorities gave top priority to the production of over one million tonnes of rice from several million hectares of flood-plains in the lower Danube, Dniester, Dnieper, Don and Kuban, Volga, Amu- and Syr-Darya watersheds and 5 to 7 million tonnes of cotton per year in Asia. Note that one hectare in Central Asia produces the likes of 4 irrigated hectares in the North Caucasus or Ukraine or 10 irrigated hectares in southwest Siberia. If enough water could be found and moved, an additional 50 million hectares could be brought into production. However, at present all available residual water reserves of the Amu-Darya and Syr-Darya watersheds have been set aside for irrigation of land typified by significant natural accumulation of salt due to the specific role of systemic droughts on chemicals built-up in the surface layer (Kovda, 1984).

Chemicals

The use of pesticides further exacerbates the problem. Pesticides are introduced onto 80% of all arable lands. (In the U.S. they are applied to only 60% of all arable lands, most of which are planted with industrial crops.) At least 30% to 70% of those pesticides drain into South European and Asian rivers. The

perennial accumulation of pesticides and other chemicals accompanied by the overuse of water has resulted in the massive salinization of irrigated land. This, in turn, has reduced the harvests of cotton, corn, and grain in the USSR by 20%-30%, 40%-50%, and 50%-60% respectively. Excessive use of pesticides generates losses amounting to $2 billion annually (Yablokov, 1988).

Biological methods of pest control were introduced to over 30 million hectares of arable land during the last decade in an effort to reduce chemical contamination of the soil and combat crop parasites. Nonetheless, biological pest control is not a popular trend in the Soviet Union. For example, in 1980 the agriculture industry received 18.7 million tonnes of pesticides and fertilizers, but in 1985 the volume increased to 26.7 million tonnes (State Sanitary Inspectorate, 1988). Plans for the next 25 years rely heavily upon chemical control of crop parasites.

Agricultural discharges compounded by river depletions are responsible for excess chemicals and salinity to such a degree that residual flow cannot be used as a source of drinking water. Similarly, water is unsuitable for irrigation unless it is regularly flushed out with more water.

Impact on Fisheries

In addition to the above miscalculations, extraordinary monetary losses affecting commercial fisheries alone amounted to between $2 billion and $4 billion a year over the last two

decades. The commercial catches in the most productive basin--the Sea of Azov--have undergone a severe decline. Such losses have put into question the validity of the notion of cost-benefit and trade-off analyses (one fish versus one tonne of grain, or one kwh, etc.) in the light of patent ecological decay of ecosystems and extirpation of fish and other natural resources. The combined effect of agricultural runoff and irrigation seepage carrying thousands of tonnes of fertilizers, pesticides and organic washouts from the croplands of the south contaminated surface and ground water supplies and disrupted the food chains in receiving basins (Dorst, 1988; Goldman 1972; Gusev, 1972, 1975; Literaturnaya gazeta, 1988; Pravda, 1988). This situation has caused drastic increases in the organic and inorganic load to estuaries and coastal waters (Bronfman, et al., 1979; Baidin, 1980; Volovic, 1986; Micklin, 1988). Ultimately, less freshwater reached the estuary/sea ecosystem and the quality of water that did reach it deteriorated (Rozengurt, 1969, 1974, 1983, 1981, 1988, 1989; Khlebovich, 1974; Krotov, 1976; Bronfman, 1985; Baidin and Kosarev, 1985 etc).

5.6 million hectares of land in Soviet Central Asia and Southern Kazakhstan need immediate reclamation from salinization, secondary salinization and resultant soil degradation (Voropaev, Novi Mir, #7, 1987, p. 183). Before this damage occurred, these areas produced 6 to 7 times the harvest yield of the Northern European USSR. Annual economic losses of Aral Sea fisheries are $100 million annually (Ponfilov et al., Novi Mir p. 200), while

agricultural, municipal and fishery losses amount to $3.0 billion dollars annually.

Numerous field observations on the Danube-Dniester, lower Dnieper, North Crimea, lower Kuban and other irrigation systems of the south during the past 10 to 15 years of their operation have demonstrated that continuous excessive watering converted the black soil into lumpy masses in some places, or thick crust in others. The surfacing of subterranean water due to generally raised water tables is now a widespread phenomenon which leads to the salinization of millions of hectares of arable land between the Danube (Europe) and Syr-Darya Rivers (Central Asia). As a result, the gaseous, redox, and biochemical regimes have become unfavorable for any vegetation cover. The problem is exacerbated by use of heavy machinery which compresses the loamy topsoil. Once fertile lands are now so encrusted from calcification that the surface layer cannot be broken by an ax. Thus, the rich black soil is converted into a barren monolith. Similar processes occur even faster if lands are irrigated by alkaline waters as is the case with the Sasyk irrigation network in South Ukraine.

While major traditional crops of the south (rice, cotton, some vegetable, fruit and fodder crops) are impossible to cultivate without ample watering, it is also worth recalling that the fundamental agricultural crops of Russia--the grains--were cultivated on the fertile black soil for centuries without modern irrigation techniques. According to widespread opinion, the current poor food production, even in the Central Asia, is largely

the result of Soviet farm management, and is only marginally related to unstable weather conditions or insufficient precipitation (Medvedev, 1987). In practice, the principal cause of these problems is rooted in man's alteration of the physical parameters of ecosystems to levels that have exceeded the ability of these systems to maintain their natural balance.

Political Ramifications

The above discussion gives strong support to the statement that if utilization of freshwater in the south of the USSR does not take natural limitations into consideration, ecological and economic catastrophes will plague the major water basins of the country as a whole. In other words, the competition for water has reached dangerous proportions. Extensive water withdrawals from the upper and middle part of south Asia, where the majority of people are Kirghiz, Tadzhiks and Uzbeks, have caused a decline in water availability and worsening quality of life for the three million Kazakhs, Turkmens and Karalpakians who live and work in the lower Amu-Darya and Syr-Darya regions and their deltas.

In the absence of significant water conservation measures, and if no new water sources are tapped by the year 2000, 5 million people (10% of the local population) will have to be relocated from lower river watersheds at a cost of $20 billion. The problem of relocating or transferring part of the Siberian river runoff begins to carry overtones of racism. The question has arisen whether the ecological disaster to a traditionally Muslim culture,

the Uzbeks, in particular, should be redeemed by the pure, clear water of Russian Siberian rivers. Renowned Soviet scientists and writers are publishing numerous articles about the danger to the Russian heritage, to Russian national monuments and to Russian culture, should the Muslims get 'Russian' water. Almost the same problem exists between Moldavia and Southern Ukraine with respect to water from the Dniester River. Thus, a water war is looming over the relationships among the southern republics themselves and betweem them and the central government.

Water Diversions: "Project of the Century," or Disaster Narrowly Averted?

This infamous project was introduced in the late 1960s by a conglomerate of Federal and Republic institutions (Gerardy, 1968; Voropaev, 1984; Micklin, 1983, 1986; see Figures 3 through 6). The group consisted principally of the water establishment--the Hydroproject Institute and the Institute of Water Problems, Moscow--and a cluster of water and agriculture industry institutions in Central Asia and Kazakhstan. M.A. Suslov's propaganda apparatus called it the "Project of the Century."

This project encompasses several complex schemes of water transfer facilities from the Arctic Ocean watershed to the Atlantic Ocean watershed in order to alleviate impending water shortages in the enormous cotton and rice growing areas, mainly in Soviet Central Asia and South Kazakhstan. In addition, it was assumed that residual and returning water runoff would prevent the complete destruction of the Aral sea ecosystem and might relieve

the lower Volga and the Sea of Azov of the chronic water deficit that originated from excessive water withdrawals for the irrigation needs of a large rice growing industry and for power plants.

In the late 1970s "successful" attempts were made by Hydroproject institutions in Kharkov and Moscow, by marshalling 25,000 employees scattered throughout the country, to link the interdependence of water requirements for the South Ukraine and Moldavia with the Siberian schemes.

The justification for these strategically important projects that included hydro, thermal and atomic power plants, and many other industrial complexes in Northern and Southern European USSR, North Kazakhstan, Western Siberia, Mangyshlak and Taimyr Peninsulas, was the necessity to mitigate water shortages that appeared to be otherwise inevitable by the end of the century. It was ascertained that if the current linear trend in irretrievable water consumption were to be maintained, water withdrawals in the south would, by the year 2000, exceed by 2 to 2.5 times the present water use of 300 to 350 km^3 per year. In this case, the water deficit could reach 100 km^3 per year (Voropaev, 1984). Thus, it will take only ten years to arrive at water shortages comparable to the current total water accumulation behind large dams (equal to 100 km^3).

According to the projects' descriptions (Voropaev, 1984), water conveyance facilities would carry 80 to 100 km^3 in an average year to the south where water would be distributed,

through inter- and intra-basin systems of reservoirs, among different watersheds and consumers. The research performed by 68 thousand people from over 100 Federal and Republic institutions cost the country about $100 million, while its practical implementation would have required spending over $100 billion (Reymers, 1988). The area affected by these projects would total 12 million km^2, slightly more then half the landmass of the USSR, equivalent to the entire area of Europe. This newly formed watershed would comprise 600,000 km^2 of lakes, and its total surface runoff would amount to 2,200 km^3 of freshwater (exceeding the total surface runoff of the USA without Alaska, or that of India). It was recognized that almost 10^5 km^2 of adjacent seas would also experience the impact of the projects. However, it could provide a water supply for the next 40 to 50 years.

Nonetheless, environmental groups and scientists have underscored the falsity of the narrow approach taken by the All-Union State Design and Research Institute for Water Resources Construction and Surveying, the Research Institute on Diversion and Redistribution of Northern and Siberian Rivers, and the Institute of Water Problems, among 97 other institutes, regarding their enforcement of this ambitious proposal.

The environmentalists have noted, for instance, that extensive reclamation of arid lands by washing out surface salts would exacerbate the already observed elevation of ground water levels, which itself increases soil salinization and decreases soil fertility. More importantly, they have argued that there are

ecologically sound alternatives to the water diversion strategy. Thus, improved irrigation efficiency, such as nighttime irrigation based on drip systems, would possibly save 10 to 20 km^3 of fresh water annually. By lining the UzSSR canal network (168,000 km of which remain unlined), seepage and percolation losses can be trimmed by 2 to 4 km^3 annually. The revival of crop rotation and more cautious application of pesticides and soil additives will significantly improve crop yields. These and other aspects were discussed at a CPSU meeting on "the Unsatisfactory Use of the Natural and Economic Potential of the Agro-Industrial Complex in the Uzbek, Tadzhik and Turkmenian republics" (Pravda, 20 June 1987).

Even though the north-south river diversion project was officially cancelled in 1986, some parts of the scheme continue to be openly debated in the Soviet press. Moreover, it now appears that in some cases, such as the Volga-Chogray canal, the local initial stage of river diversion projects has already been partially implemented. Water drainage systems were significantly modified; irrigation systems were built in anticipation of increased water flow; and the production of crops that require such water flow--for example, rice and cotton--was restructured. The end result of this is that, in the absence of increased water reserves, regional economies cannot function properly.

The battle to reach a viable and comprehensive solution to the Soviet Union's water problems seems to have reached an impasse given the fact that implementation of the river diversion projects

is harmful to the environment and may not be possible. The project is even more problematic if one considers the impending climatic and political uncertainties that overshadow project implementation, as well as the deficiency of economic and human resources necessary to provide the water transport from the Siberian rivers to various Southern regions. Farmlands of the south may experience a crisis situation in the event of a succession of years of subnormal wetness. Water reserves in the south are exhausted and alternative solutions regarding water conservation and the alleviation of water pollution are proceeding very slowly. Besides, many questions have been left untouched pending modification of the organizational structure of nationwide water management.

Several important questions need to be addressed: How to mitigate massive water and soil contamination over millions of hectares of watersheds without slowing down food production and energy output? The cleaning of the environment requires many years of work and astronomical expenditures ranging from $50 to $100 billion ($2 billion per km^3 of contaminated water and $5 billion per million hectares of structurally destroyed and salinizied land). How to balance the needs of agricultural and riverine-estuarine systems of the southern seas under current and future development without sacrificing demands for water by industrial and municipal users? In the light of frequently occurring dry years affecting over 60% of arable land and the verifiable natural limitation of surface and ground water supply--especially

unsatisfactory in semi-arid and arid zones of the USSR--this question has serious implications. What will the Soviets do with the several million people involved in servicing the irrigation programs and their operational network of nearly 700 thousand km if the programs themselves are being drastically curtailed? How will irrigation machinery and logistics be economically reoriented from the large integrated water projects to small-scale optimal use of a complex soil mosaic in connection with local water resources? How will the Soviets incorporate a large number of Central Asian agricultural workers in less lucrative jobs than cotton and food production to economically sustain the exploding Muslim and other Soviet populations? How to avoid political uncertainties and turmoil between neighboring republics over water issues?

The accumulation of uncertainties relating to the Siberian diversion has, for the time being, brought an end to project development. In practice this "project of the century" has enormous ecological, economic and political problems.

However, it should be stressed that rejection, for the time being, of the north-south Siberian river diversion project is a significant event, bearing in mind that millions of dollars have already been spent on the design and field work. Also, widespread dismay exists over this action in Muslim republics which believe that the Siberian water is imperative to their very existence and future progress.

The Volga-Chogray Canal

This part of the "Project" was approved in 1985 by the Councils of Ministers of the Kalmyk ASSR and the RSFR, the Astrakhan and Stavropol province Party committees, the USSR's Ministry of Land Reclamation and Water Resources, and other offices, as a part of the Siberian project (Figure 7). The main objectives of the Volga-Chogray project were: (1) to transfer about 2 km^3 of water from the lower Volga through the Kalmyk Steppe and into the Chogray Reservoir in order to provide a stable water supply for irrigation of the 135,000 and 75,000 hectares of dry farmland in the Stavropol province and Kalmyk republic, respectively; (2) to improve rural drinking water quality and supply; (3) to reduce agricultural contamination of the Kuban' Delta lagoons where the concentration of hazardous chemicals is 100 times the permissible level, and (4) to mitigate the impact of droughts (which occur on an average of once every three years) and concomitant effects on livestock numbering 330,000 cattle and over 4 million sheep (Pravda, 9 May 1988). The cost of the 350 km canal was assumed to be equal to $688 million; the additional annual net profit was projected to $180 million through marketing of meat, milk, grain, vegetables and wool.

Construction of the canal began in 1986, and by 1987 the government had spent $60 million digging about 30 km of the canal. However, the public outcry under "glasnost" coupled with an executive order has halted this work. The reasons for overturning the previous decision are: (1) the canal will cross highly salty

soil, and hence will dilute the salt and carry salty water unsuitable for irrigation, (2) the project assumed that the canal will be unlined, hence around 30% of the water will go to waste and will waterlog the soil, transforming the land into unproductive "solonchaky" (saline and sodic soils), and (3) the actual cost of the canal was hidden by its promoters and will exceed $2 billion.

IV. LATEST DEVELOPMENTS UNDER GORBACHEV

Policy Reassessment

The current Soviet leadership has decisively demonstrated its determination to stop using large integrated programs as the major method for enhancing food production. Today, the Party favors the use of "intensive" technologies in agriculture (as opposed to "extensive" in the past) that can liberate water for other needs and decrease pollution. This has enforced the notion that the Siberian and other new projects are unnecessary and expensive ventures. Water efficiency measures and alternative crop production techniques are capable of delivering increased agricultural yields while saving water and preserving soil quality and traditional standards of living. These alternatives are also closely related to concern for the inner-dynamic equilibrium of the ecosystem. In other words, when one component of the ecosystem is overused, subsequent chain reactions will create disorder within a given system. The Aral Sea is a typical example

of this distortion (Micklin, 1988).

Though a new program has not yet been enacted, several methods of soil and water conservation that would simultaneously increase crop production have been proposed. These include anti-erosion measures, the cultivation of abandoned lands, the use of drip irrigation, expanded crop rotation, and more moderate use of chemical fertilizers. It was computed and verified on some field experimental sites that the economic use of modified drainage networks and crop rotation would, by itself, save up to 70 km^3 of freshwater per year in the Southern belt of the country. The water saved equals 60% to 70% of the proposed water withdrawals from the Siberian rivers!

The main newspapers, Pravda and Isvestia, and other media sources described the behavior of leading institutions in quietly pursuing their ill-conceived projects as lacking in "civic responsibility for the fate of their homeland." Thus, one more part of the ambitious scheme of the "Project of the Century" has failed the test. In this context, a comment by the editor of Novy Mir, Sergei Zalygin, that Soviet public opinion has succeeded in forcing the leadership to cancel the water diversion project, appears to be correct to some extent.

The resolute rejection of some projects previously approved by the Federal or Republic governments has become possible because risk assessment analysis of alternatives has shown the adverse ecological and economic consequences of existing projects whose major features served as prototypes for proposed future

developments. This analysis demonstrated that implementation of the proposed projects might be ecologically damaging and economically unsound.

The new government (Gorbachev's reformists), with the help of the public at large, has started to reconcile current demands for water with consideration of long-term water availability. An attempt is being made to mitigate the deterioration of water and soil ecosystems and to provide an optimal environmental regime while taking the welfare of the population into consideration. The Academy of Sciences, the State Committee on Science and Technology, and the Ministries of Agriculture and Water Resources are taking a new look at the current precarious situation.

The reevaluation of economic and ecological effectiveness of river development has undergone stringent scrutiny in several areas:

- geophysical and biological consequences of seasonal and annual water withdrawals (to fill power plants' reservoirs) and diversions (intra-basin water conveyance canals) on renewable and non-renewable natural resources of river watersheds.
- the effect of a linear approach to water development on the stock of fisheries and their decline in the deltas and shelf zones of adjacent seas.
- the economic effectiveness of current methods of irrigation in the Ukraine and the Central Asian republics.
- regional economic and societal priorities in water development and consumption versus freshwater availability in years of subnormal wetness.
- ways and means to mitigate contamination of the drinking water supply by industrial and/or agricultural pollution as a result of the lack of treatment of waste water,

residual runoff retardation and increase of detention time of pollutant accumulation.

- the economic and societal consequences of long term population growth versus natural limitations in water supply in semi-arid and arid zones of the USSR.
- analysis of the effect of current and future chronic water deficits in the Southern USSR on the political situation and on the interrelationship among the different republics and the federal government.

These calculations have brought about a new progressive concept in resources development, as opposed to the utilitarian approach of "scientific communism." The new approach to resources development is to balance the use of natural resources and priorities, and to seek conservation, development and preservation of those resources, or, in short, balanced natural resource use (BNRU). This concept takes into consideration the explosive growth of population, technology and the natural limitations of resources development imposed by the global environment. In other words, BNRU is based on a systems analysis of economic activity in a non-isolated environmental setting, be it a river basin with a clearly identified watershed, a sea or an estuary, or any land-based, well-defined ecosystem where many enterprises draw on one or several renewable natural resources. Each of these together--population, infrastructure, and natural resources--are considered to be a subdivision of the global environment, called the biosotsial'naia sistema (bio-social system), or BSS. Each renewable resource in a BSS is considered to be a proizvoditel'naia sila (productive force), and consequently, all

of these must be considered in economic mechanisms along with other resources: human, land, surface and ground water, forest, etc. To keep the "operation" of natural resources and cycles economically effective, different ranks of goals for environmental protection also must be specified for a BSS (Figure 8).

In the light of the above, field observations coupled with ecological-economic modelling are assumed to be the best tools for short- and long-term predictions of the behavior of a BSS.

At present over 130 academic and federal institutions along with numerous local inspectorate laboratories are working year-round collecting and analyzing a wide variety of ecological, sanitary and economic data whose indispensable value for current and future decision-making is without question. Since the 1960s over 6,000 automated and 28,000 partially automated and man-managed hydrological, meteorological and agrometeorological stations have become operational throughout the country. In addition, several dozen ships of different sizes and capabilities are plowing the fourteen seas, gathering data. Special emphasis is placed on investigating and predicting the short- and long-term impacts of modifications to the river watersheds on the environmental and economic development of the southern seas of the USSR. At the same time, special attention is being paid to the collection and analysis of all available related information published in Western and developing countries and the USA (though with 3-6 months delay due to translation). This task is being conducted by the All-Union Institute of Scientific and Technical

Information (Moscow). Therefore, the leading Soviet environmental specialists are well aware of the successes and failures in resources development in many countries. The gist of this information is sent on a quarterly basis through special institutional entities to different federal offices, including the Ministry of Defence, the Committee on Science and Technology of the USSR, the Ministry of Fishery, the Ministry of Agriculture and the Ministry of Water Industry, and some Departments of the Central Committee of the Communist Party.

Much of the condensed information is used by Soviet diplomats in their analysis of, for example, the international market for resources development in order to provide Soviet technical specialists with an opportunity to participate in large-scale resources development projects (for example, the Aswan Dam), or to foresee fluctuations in the prices of food and other commodities. It is worth noting that the Soviet Embassy in Washington has, at present, a Department of Water Resources.

The impact of various scenarios of economic development of large geographic regions on both national and international levels is also considered. In this context, it is believed that the final scenarios will provide an opportunity to perform an objective analysis of economic-ecological alternatives and to recommend one which would best incorporate the optimal balanced development of the competitive components of a BSS.

To enforce this new decision-making, many leading Soviet experts on environmental laws suggest (Nash Sovremennik 1985,

1987, Nauka i Zhizn, 1987, 1988) that long-term programs affecting large subdivisions of the biosphere should be the subject of nationwide discussions in conformity with Article Five of the new Soviet Constitution.

Soviet economic planners have taken several steps to improve water quality and prevent unnecessary water losses. Some of the measures include: nationwide water quality control to be carried out by a network of sanitary inspectorates; the construction of recycling systems in technological and agricultural industries that were marked by extremely dangerous pollution, especially from agricultural drainage networks of the southern USSR; improved waste water treatment in areas known for untreated discharges, such as the petrochemical industries of the Western Ukraine or the Middle Caspian, where discharges amount to over 100,000 tonnes of sewage and 10,000 to 20,000 tonnes of oil products per year in each region.

Special attention is being focused on the necessity for emergency springtime water releases from upstream reservoirs in order to provide reasonable conditions for the migration and spawning of valuable fish in lower river-delta-estuarine systems.

Institutional Developments and Public Involvement

It is recognized by many leading institutions that water conservation in conjunction with efficient water treatment is the only way to prevent the inception of unpopular and ecologically harmful projects in the USSR such as the Danube-Dnieper, Volga-

Don-2, and Volga-Chogray canals and Siberian inter-basin water conveyance systems.

Prompted by the advent of the grave ecological and economic conditions described in this report, in June of 1987 the Politburo discussed the impact of these problems on sanitary conditions and production efficiency across the country. As a result of this meeting and consequent studies, an executive mandate of January 1987 commanded that a thorough overhaul and reconstruction of laws pertaining to the protection of nature be undertaken. Inspired by this ruling, a new environmental association, Ecology and Peace, was founded in October 1988. This group includes scientists, writers and intellectual activists from a wide range of government institutions who have set themselves to the task of reviewing the impact of past and current projects on the natural environment. Also born of this mandate was the new Federal Committee of the USSR on the Preservation of Nature (Goskompriroda). To this organization have been delegated powers to adjudicate all environmental construction and the disposition of labor forces. It can enforce project restriction and cancellation.

According to a federal publication and the statement of the Vice President of the Academy of Sciences, Valentin Kortug, a 20-year national program for the rational use, preservation and balanced economic development of natural resources has been established. The program has the active participation of scientists, the State Committee for Hydrometeorology and Control

of Environment (STHCE), the State Committee for Public Education and the Soviet Peace Committee.

In its attempts to tackle environmental problems, the government is relying increasingly on public opinion. Among its most decisive actions to date are:

1. On 1 September 1988 the Politburo of the CPSU approved a radical large-scale reconstruction of the irrigation and drainage network in Soviet Central Asia and Kazakhstan in order to save the Aral Sea. It was the first time in the last decade that storages in the Amu-Darya and Syr-Darya rivers were obliged to release 12 km^3 of water to the sea, as opposed to only 2 km^3 from the Amu-Darya in the preceding five years.

2. Put a halt to the construction of the Cheboksarskaia, Nizhne-Kamskaia (Volga), Katunskaia and Turukhanskaia (Siberia) and Daugavpils hydropower plants, the lower Volga-Chogray canal, the enlargement of power generating units at Chernobyl, and the new Krasnodar nuclear power plants in the Kuban' river basin. Construction of the dam and locks in the Kinburn Strait of the Dnieper estuary and in the Kerch Strait of the Sea of Azov have been halted.

The construction of over 30 power plants of different types with a total power of 80 million kwh is opposed by serious reformers both in the government and in the public at large (Pravda, 3 January 1989). Moreover, in Georgia students have blocked the construction of the Hudonskoy hydropower plant.

Between 1986 and 1989 over $10 billion per year were allocated

to solve some environmental problems, 65% of which was for water protection. This compares with $1.5 to $3.5 billion before 1985.

Different groups of concerned citizens have formed "The Association for the Support of Ecological Initiatives" (ASEI, Department of Geography, Moscow State University, Moscow, 119899, USSR, tel. 939-3842; 939-2740). The ASEI has been established by The Foundation for Social Invention (FSI). The latter represents a conglomerate of scientific entities of the USSR Academy of Sciences and Moscow State University.

The union between FSI and ASEI provides a wide spectrum of environmentalists with free access to scientific information to carry out independent environmental impact assessments on a variety of environmental and economic topics, and make the results of their findings easily available to the mass media. In practice, the current public movement is an unprecedented event in Soviet history and, without any doubt, its vitality on the political scene is mainly due to "glasnost".

ASEI activities address the following topics:

- The USSR and global environmental problems
- Comparative analysis of ecological expertise (Environment Impact Assessment) in the USSR and worldwide, with emphasis on the American approach to analysis of urgent environmental problems, ways and means of decision-making, economics of resources modifications, societal and international achievements, etc.
- The contemporary political, economic and environmental situation in the USSR
- Environmental management in the USSR, in general and by republics, historical views and perspectives

- Environmental education in the USSR and the countries of Eastern Europe
- The scientific basis of the public ecological movement
- The role of "glasnost" and "perestroika" (reconstruction) in current and future environmental management in the USSR
- The ecological, economic and political implications of environmental degradation of water and arable land in the USSR to the end of this century, including the European industrial centers, Moldavian and Ukrainian republics, Soviet Central Asia, Baltic republics, etc.
- The air quality and future of forest resources in industrial Russia and Northwestern Siberia
- The economic development and ecological future of the Soviet Far East
- The ecological strategy of resources preservation and restoration

The ASEI has full rights as a legal entity "to promote non-governmental independent expert review of different projects, scientific and educational programs, information and popularization, publishing, exhibitions and festivals, as well as stimulating communications and contacts among public ecological movements, groups and individuals both at national and international levels." The ASEI does not have the right to order or promulgate instructions and directions over government policy but can use legal means at any level to halt ecologically damaging projects or require their modification or reconsideration.

Therefore, the ASEI seeks democratic forms of cooperation between the government and environmentalists to establish effective public and scientific control mechanisms over bureaucratic decision-making and management by temporary political

nominees.

The Uncertain Future

Scientific communities and environmental groups have a sense of urgency concerning the enormity of pending problems between the west and east, north and south of the USSR. It is apparent that the new environmental policy may attain some positive results in partially restoring renewable resources and the surrounding environment if simultaneous painful, expensive and coherent modifications of many branches of economic planning and development take place.

However, the implementation of new principles of balanced development in the national economy and use of natural resources will require the retraining, re-employment and replacement of large groups of productive forces, the introduction of new computerized information technologies, the assimilation of Western experience in economic and environmental planning, the decentralization of control over regional and republic resource management, and the development and introduction of a new system of economic incentives, such as pricing, for the preservation of natural resources.

During the 27th Party Congress and 19th Party Conference in 1986 and 1988, Soviet leaders vowed to preserve the environment and at the same time reach self-sufficiency in the supply of food and consumer goods in the near future. How these goals can be reached when current agricultural production is lower now than it was at the beginning of the 1980s, and when water management of

hundreds of reservoirs and many hundred thousand kilometers of irrigation networks are in complete disarray, remains to be seen.

Table 1

MAN-INDUCED ANNUAL RUNOFF REDUCTION IN THE SOUTH SEAS OF THE USSR

(Cubic kilometers)

	Normal	Annual reduction					
		1970		1985		2000	
Caspian	295	22	8%	44	15%	90	31%
Aral	54	9	17	50	93	52	96
Azov	41.1	7.7	19	16	39	21	51
North of the Black Sea	64.5	12.0	18.6	30	47	44	68

Source: Compiled after Golubev and Vasiliev, 1984; Rozengurt, 1989

Table 2

THE MAJOR EXAMPLES OF THE INTERBASIN AND INTRABASIN WATER CONVEYANCE FACILITIES

River	Canal	Volume km^3	Length km	Major water users
Interbasin water tranfers				
Volga	Volga-Moscow	2.3	100	Municipal, Industry
Volga	Volga-Ural	3.1	400	Agriculture
Amu-Darya	Karakum	8-10.0	1100	Agriculture
Dnieper	North Crimea	8.2-12.0	400	Agriculture
Dnieper	Dnieper-Donbass	1.2	??	Industry
Irtysh	Irtysh-Karaganda	2.2	460	Industry
Samur	Samur-Apsheron	1.7	200	Agriculture, Industry
Intrabasin Water Transfers				
Naryn	Great Fergana	6.0	350	Agriculture
Syr-Darya	Golognay Steppe	4.4	?	Agriculture
Kura	Upper Karabakh	3.4	170	Agriculture
Kura	Upper Shyrvansky	2.4	120	Agriculture
Kuban	Nevinnomyssky	1.9	50	Agriculture
Don	Don-magistrial	1.0-7.9	110	Agriculture
Terek	Tersko-Kumsky	2.7	150	Agriculture

Source: modified after Golubev and Vasil'ev, 1984.

Table 3

IRRIGATION NEEDS AND CLIMATOLOGICAL CONDITIONS

Regions of different wetness	US	USSR
Region of stable wetness (700 mm/year)	60%	>1% precip.
Region of unstable and subnormal wetness (precip. 400-600 mm/year)	29	59
Semi-arid and arid regions (less than 400 mm/year)	11	40

Source: Ovchinnikov, 1985, p. 16.

Table 3a

IRRIGATED LAND
(Millions of hectares)

Country	Area of Irrigated land (millions of hectares)	Irrigated land
USSR	9.0	8%
PRC	48.0	47
USA	25.0	18
India	57.0	34
Japan	3.2	58
Bulgaria	1.2	28
Rumania	2.3	22
No. Korea (KPDR)	0.8	36
E. Germany (GDR)	0.9	15
Hungary	0.5	9

Source: Ovchinnikov, 1985, p. 17.

Table 4

SUBNORMAL RUNOFF (75% PROBABILITY OF EXCEEDENCE OF MAJOR RIVERS OF SOUTHERN EUROPEAN PART OF THE USSR AND AVERAGE WATER CONSUMPTION WATER NEEDS)

(Cubic kilometers)

River	Total Runoff	Water Users					Residual Runoff Needs[1]	Total Water Needs	(+)Excesses or (-)Deficit
		Irrigation & other ag. needs	Municipal, industry needs	Fishery	Evaporation from reservoirs	Total rise			
Volga	221.5	15.6	4.4	2.9	19.2	42.1	168.0	210.0	+11.4
Dnieper	45.4	14.7	6.7	0.6	3.2	25.2	16.0	41.2	+ 4.2
Kura	25.5	13.9	0.8	0.7	2.5	17.0	5.5	23.4	+ 2.1
Don	21.7	6.0	2.0	0.7	2.0	10.7	21.0	31.7	-10.0
Kuban	12.0	7.2	0.4	2.3	0.2	10.1	2.0	12.1	- 0.1
Terek & Sulak	15.4	6.4	0.7	1.9	0.0	9.0	4.5	13.5	+ 1.9
Dniester	8.3	2.6	0.8	0.4	0.2	4.0	0.5	6.5	+ 1.8
Ural	5.3	1.1	1.1	0.8	0.9	3.9	5.5	9.4	- 4.1

1 Sanitary, navigation and power plants needs

Source: Modified after Golubev and Vasil'v, 1984

Figure 1

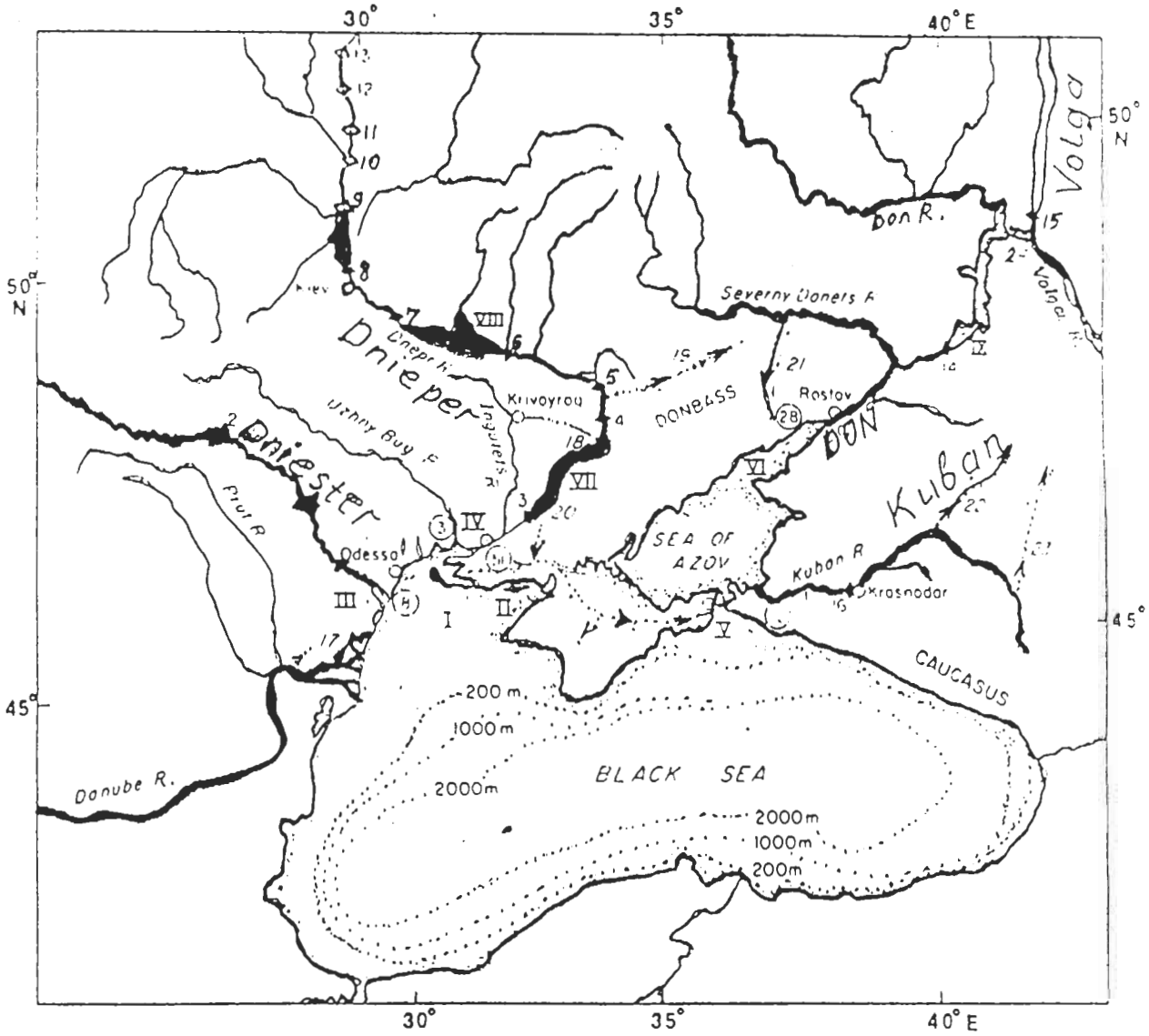


Fig 1 Maior rivers, estuarine regions, and associated geographical settings of the Black Sea used in the study (depth in meters). (I–IX) *Water Bodies*: (I) Nothwestern Black Sea, (II) Karkinitsky Zaliv (Bay), (III) Dnestr Estuary, (IV) Dnepr Estuary, (V) Kerch Strait, (VI) Taganrogsky Zaliv (Bay), (VII) Kakhovskoye Vdkhr (Vodokhranilishtche-Storage Lake), (VIII) Kremenchugskoye Vdkhr, (IX) Tsymlianskoye Vdkhr. (1–8) *Hydropower stations* (1) Dubossary, (2) Mogilev-Podol'sky, (3) Kakhovka, (4) Dneproges, (5) Dnesprozderzhinsk, (6) Kremenchug, (7) Kanev, (8) Kiev, (9) Lubech, (10) Rechista, (11) Zhlobin, (12) Viliakhovka, (13) Mogliyow, (14) Tsymliansk, (15) Volgograd, (16) Krasnodar. (17–24) *Irrigation and water supply channels*: (17) Danube-Sasyk, (18) Dnepr-Krivoy Rog, (19) Dnepr-Donbass, (20) Dnepr-Crimea, (21) Dnepr-Crimea, (21) Severny Donets-Donbass, (22) Nevinnomyssky, (23) Kuban-Kalais, (24) Don-Volga. The arrows indicate the direction of the water transport. Encircled numbers indicate the annual river water discharge in km^3/year.

Figure 2

COMPARISON OF THE AMOUNT OF MARKETABLE GRAIN PROCURED DOMESTICALLY AND THE AMOUNT IMPORTED

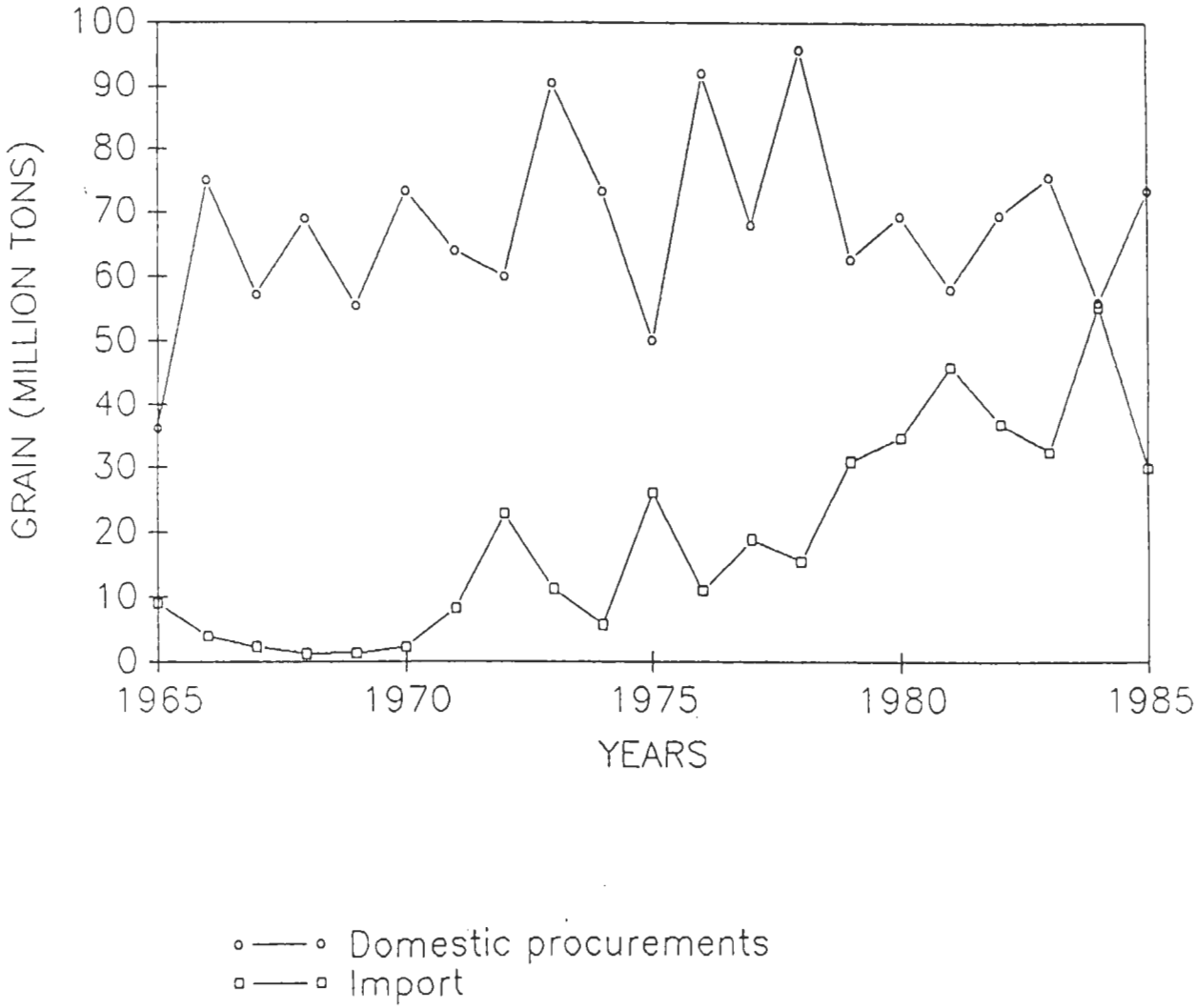
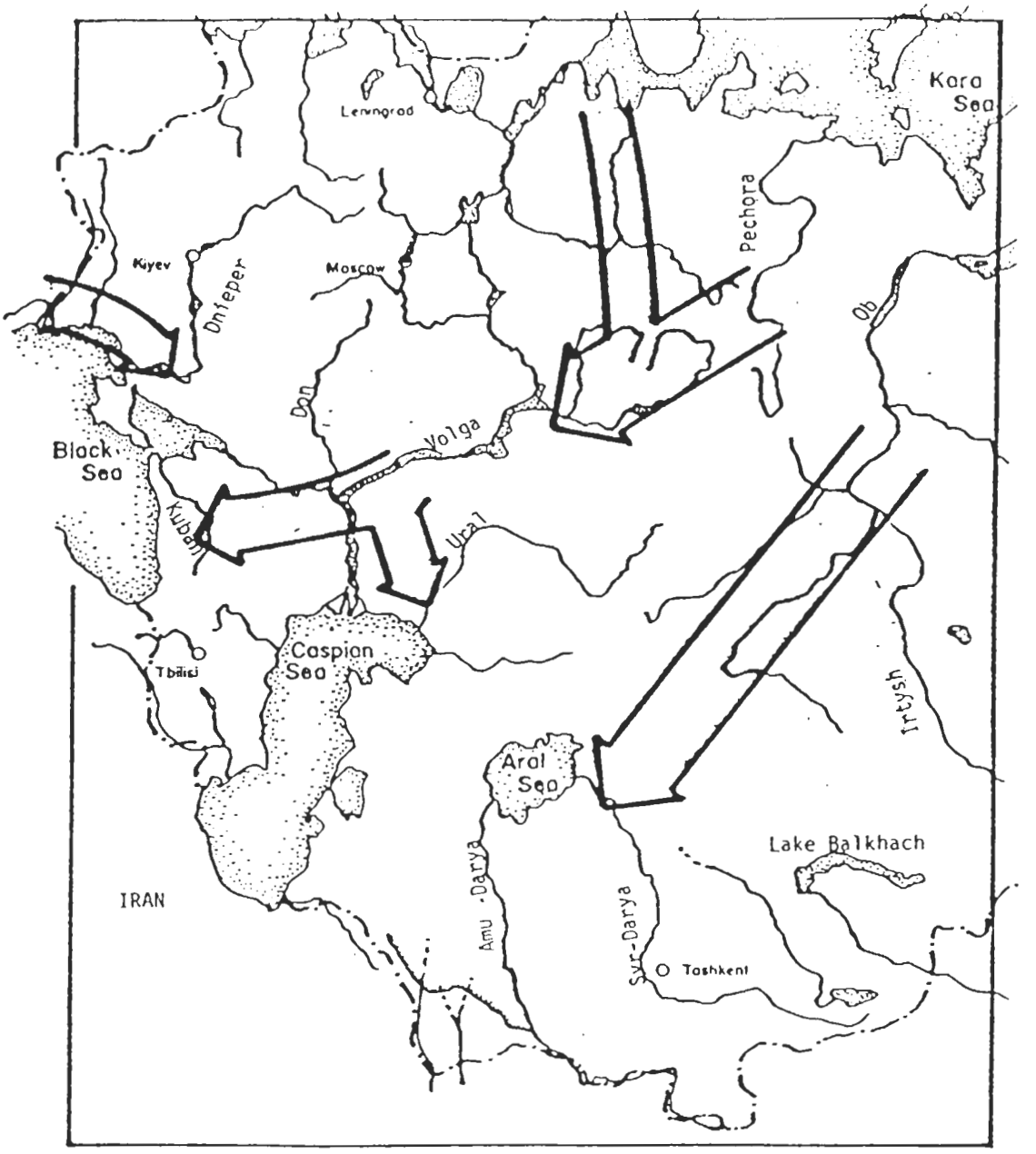


Figure 3



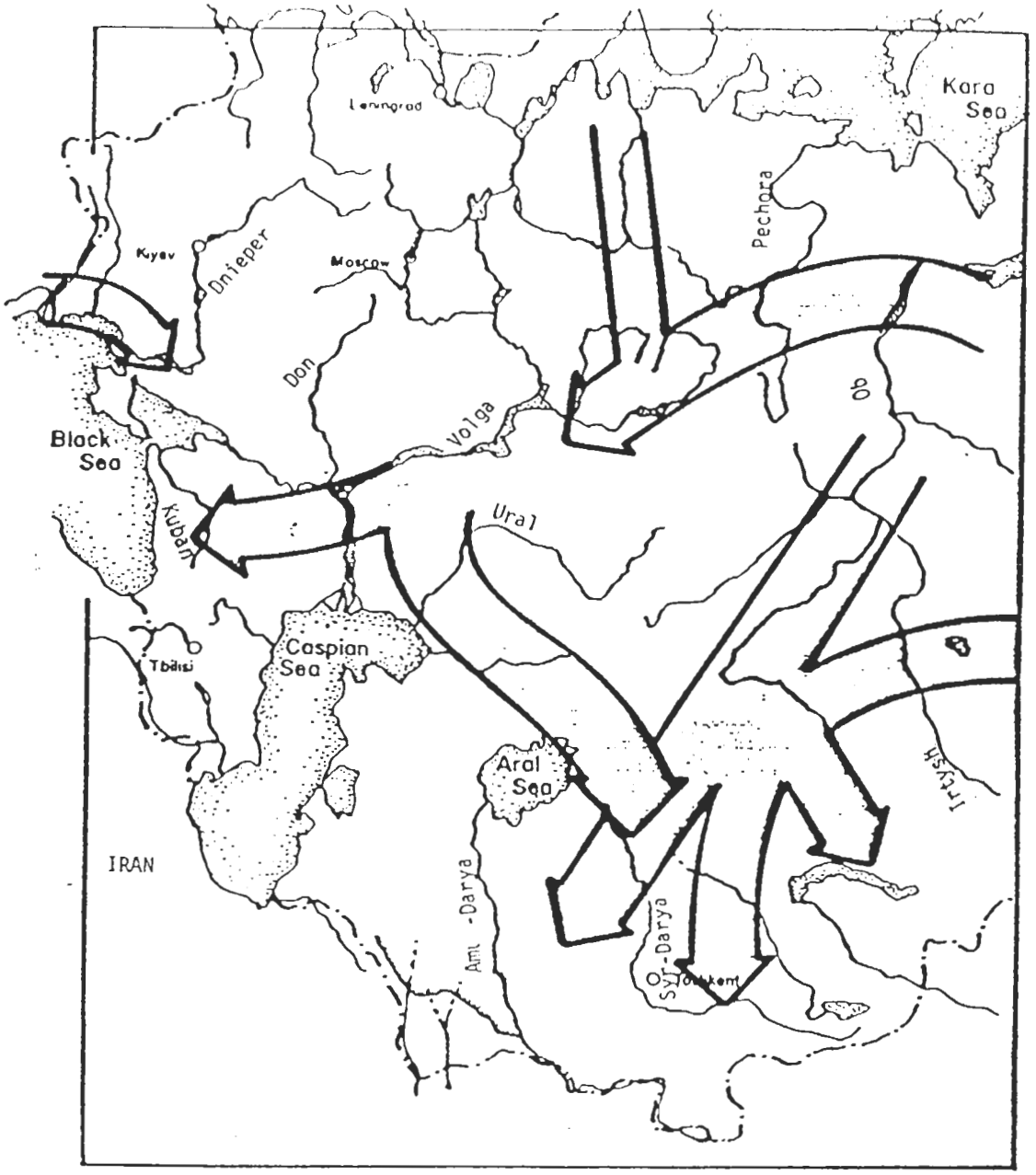
European and Asian schemes of interbasin water conveyance facilities.[1,11j]

[1]Water deficit in the European part will be replenished by runoff from the north rivers of Karskoro and the White Sea, as well as from the Danube River to the lower Dnieper and some large freshwater lakes of the northwest of the RSFSR (modified after Voropaev, 1984)

[11]The Asian deficit (Soviet Central Asia and Kazakhstan) will be replenished by the Ob River runoff.

Major interbasin routes: Pechora-Volga (length of canals 1200 Km, discharge 1000 m^3/sec, lift up 160 m); Ob-Irtysh-Syr-Darya-Amu -Darya (length of canals 3600 Km, discharge 2400 m^3/sec, lift up 150 m; Voropaev, 1976,1984)

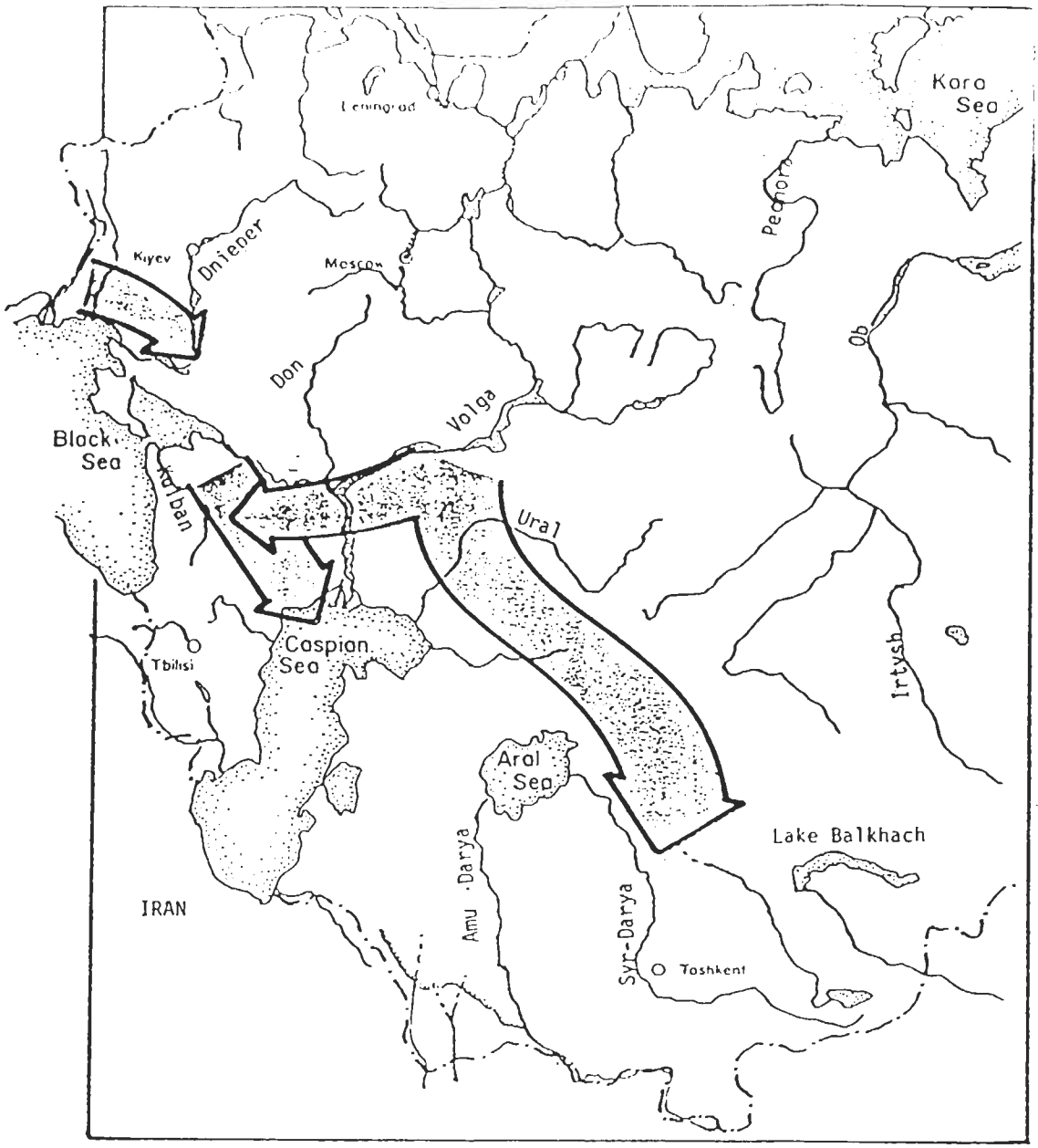
Figure 4



Combined Euro-Asian scheme of interbasin water conveyance facilities.[1]

[1]Water will be withdrawn from the Ob River through the Ural and Pechora Rivers to the Volga basin. From there water will be directed to the Soviet Central Asia and South Kazakhstan, Middle and Lower Volga Basins, North Caucasus, Kalmykia and Rostob-on-Don province. The Danube scheme will be used, as well as some northwestern river runoffs (modified after Voropaev, 1984).

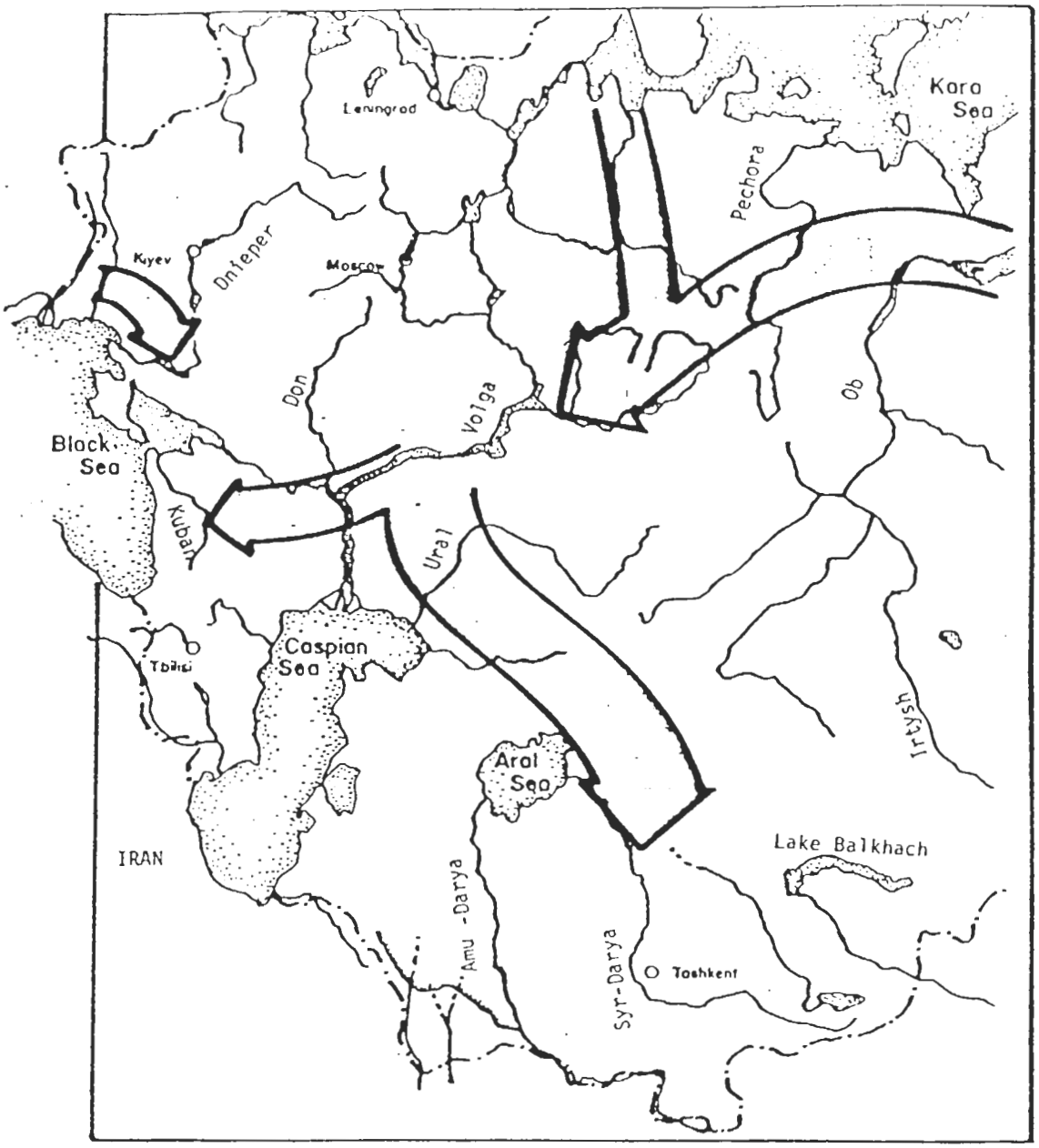
Figure 5



The Black Sea-Volga-Caspian Sea scheme of water transferring facilities (modified after Voropaev, 1984).

The Volga River will be the major source of water supply to European and Asian arid and semi-arid zones. The water deficit in the Caspian Sea will be controlled by transferring the Black Sea water over the North Caucasus. It is assumed that the North Caspian will be separated from the rest of the Sea by a dam. The local interbasin conveyance facilities will be planned.

Figure 6



All-Union unified interbasin water transferring scheme[1]

Major interbasin routes: The low Ob-Pechora-Kama-Volga (length of canals 4,400 Km, chischarge 2400 m^3/sec, lift-up 260 m), the low Volga-Syr-Darya-Amu -Darya (length of canals 2400 Km; discharge 2000 m^3/sec; lift-up 210 m; Voropaeb; 1976, 1984)

Figure 7

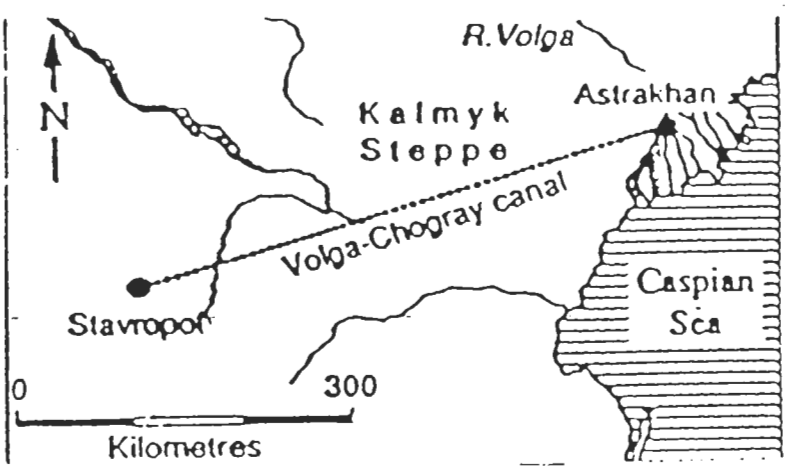


Fig. Scheme of the Volga-Chogray canal.

Figure 8

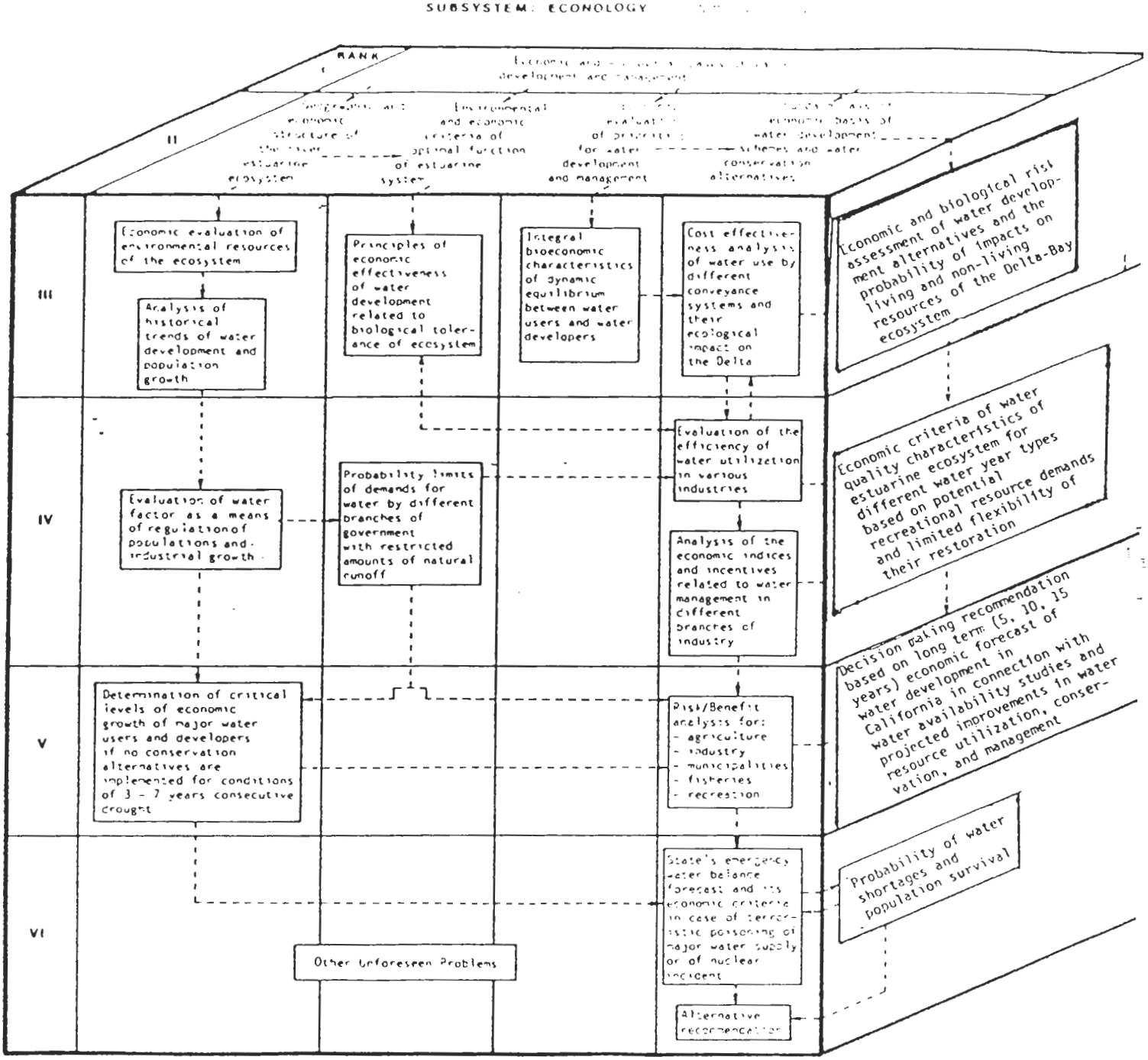


Figure Typical priorities (ranks) of investigations of the interrelations between ecological and economic indices of water development in the South of the USSR under various levels of water availability for different water users.

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